Syllabus MSNE 411 Spring 2016 rev. 12 Mar 2016 PJL

Metallography and Phase Relations – Study of microstructures that may be observed in metals and alloys using visible light microscopy, scanning electron microscopy, and other techniques, how those microstructures are produced, as well as the relationships between structural properties and failures. Required for the BS degree in MSNE.

- **Instructor:** Peter Loos **on campus:** ME 215 **email:** ploos@rice.edu
- **Office hours:** After class, by appointment, and others TBD
- **Class Meets:** TuTh 1:00-2:15pm in MEL 254
- **Prerequisites:** MSNE 301 is required. Completion of MSNE 303 is also assumed.
- **Text:** None. There will be several reading assignments from the published literature.
- **Grading:** 30% homework, 25% tests, 15% quizzes, 20% presentations, 10% vocabulary list. There will be approximately two tests, two quizzes, five homework assignments, and one presentation. Points may be deducted for assignments turned in late and for bad or missing references.
- **Absence Policy:** Missed quizzes and presentations must be made up right away. Students are expected to attend class.
- **Software:** Students will use spreadsheets such as MS Excel or OpenOffice Calc for some of the homework and test calculations. Also, MS PowerPoint or OpenOffice Impress or similar software can be used for presentations. For compatibility, all files should be saved in either XLS, DOC, PPT, or PDF format.
- **Honor Code: For every assignment** students must do all the writing, typing, calculating, and analyzing themselves, must **not** examine or copy from any work done by any student in this class (past or present), and must include and sign the Rice Honor Pledge on work turned in. Plagiarism and other academic fraud will be addressed per the Honor System Handbook. **For homework, presentations, and vocabulary lists,** students are encouraged to communicate with each other, the Instructor, or anyone else with knowledge of the subject. But **for tests and quizzes** no communication is allowed except with Instructor.
- **References:** When using information from a source other than class lecture slides or your own original work, a proper reference must be given. Use ACS format per pubs.acs.org/doi/pdf/10.1021/bk-2006-STYG.ch014 or in simpler form: http://library.williams.edu/citing/styles/acs.php.
- **Disability Support:** Any student with a disability requiring accommodations in this course is encouraged to contact Instructor after class or by email. Additionally, students need to contact Disability Support Services in Allen Center.

Lecture Topics

- History of metallography and phase diagrams. H.C. Sorby's sample preparation and microscopy in 1863 and H.W.B. Rozeboom's Fe-Fe_3C phase diagram in 1900.
- Alloys of interest: iron, steel, stainless steel, aluminum, titanium, etc.
- Length scales of interest
- Purposes of metallography: R&D, quality, reliability, yield, process development, process control, etc.
- Sample preparation techniques: sectioning, mounting, grinding, polishing, and etching (as needed) to reveal the true structure without changing it.
- Etchants for specific applications
- Safety in the metallurgy lab: machinery as well as corrosive and poisonous chemicals
- Macrostructure / macroanalysis of cast and wrought materials
- Visible light microscopy: optical components, magnification, resolution, enhancing resolution through colored filters and oil immersion, bright field/dark field, polarizing filters
- Scanning electron microscopy and x-ray microanalysis
- Quantitative metallography: ASTM grain size, lognormal grain size distribution, defects, etc.
- Binary phase diagrams: eutectic, eutectoid, peritectic, peritectoid, monotectic, etc.; cooling paths, precipitates formed.
- Isothermal transformation and continuous cooling transformation diagrams for various alloys, and their use.
- Field failures: sample preservation, types of failures, and how to recognize them.

Goals for this course:

To address ABET Student Outcomes and Program Criteria, students will have

(e) an ability to identify, formulate, and solve engineering problems
(g) an ability to communicate effectively
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

and the course will prepare graduates to:

- integrate the understanding of the scientific and engineering principles underlying the four major elements of the field: structure, properties, processing, and performance ...

More specifically, students will become familiar with

(1) many of the microstructures which occur in metals and alloys, how those result from composition and thermal history of the material,
(2) use of equilibrium phase diagrams and isothermal transformation diagrams to predict/understand microstructure and thermal history.
(3) common sample preparation and microscopy methods and microscope equipment used to observe those microstructures.
(4) the terminology used to describe microstructures
(5) how problems in the microstructure can lead to failure

References

ASM Handbook* Volume 3, *Alloy Phase Diagrams (1992)
ASM Handbook* Volume 9, *Metallography and Microstructures (2004)
ASM Handbook* Volume 11, *Failure Analysis and Prevention (2002)
ASM Handbook* Volume 12, *Fractography (1987)
Metallographic Etching *by* G. Petzow, ASM (1978)
Metallography of Phase Transformations by G. A. Chadwick, Butterworths (1972) which is out of print
Annual Book of ASTM Standards includes about 375 standards for metallography. See search results. Fondren has these on microfilm. Also ASTM has published many hundreds of Special Technical Publication (STP) books about metallography. See search results. Fondren has many of these on the shelves.
SAE standards concerning metallography, see search results.

Resources On the Web

- Interactive binary phase diagrams with accompanying photomicrographs from Virginia Tech and Cambridge Univ.: www.sv.vt.edu/classes/MSE2094_NoteBook/96ClassProj/examples/kimcon.html and www.doitpoms.ac.uk/miclib/phase_diagrams.php
- Microscopy U from Nikon www.microscopyu.com/index.html
- Crystal lattice structures from the Naval Research Lab. These were taken offline a few years ago and have to be accessed through the Wayback Machine at archive.org/web/: See http://cst-www.nrl.navy.mil/lattice/ also many useful links at: http://cst-www.nrl.navy.mil/lattice/others.html. The versions before March 2010 seem to be OK. Direct links:
  http://web.archive.org/web/20120803114251/http://cst-www.nrl.navy.mil/lattice/
  http://web.archive.org/web/20120722224347/http://cst-www.nrl.navy.mil/lattice/others.html

Journals:

www.sciencedirect.com.ezproxy.rice.edu/science/journal/00260800	Metallography
www.sciencedirect.com.ezproxy.rice.edu/science/journal/10445803	Materials Characterization
link.springer.com.ezproxy.rice.edu/journal/volumesAndIssues/11508	The Physics of Metals and Metallography

Videos:

www.youtube.com/user/MaterialsScience2000	Several good videos listed
www.youtube.com/watch?v=fc8zrgYJCJw	Metallography Part I - Macroscopic Techniques
www.youtube.com/watch?v=UuHofNW40Yw	Metallography Part II - Microscopic Techniques
www.youtube.com/watch?v=GY9lfO-tVfE	SEM
www.youtube.com/watch?v=7Z90OZ7C2jI	Vickers Hardness Test
www.youtube.com/watch?v=xEK-c1pkTUI	Dye Penetrant Inspection

Metallography:

www.msm.cam.ac.uk/phase-trans/abstracts/CP1b.html	Sample preparation for metallography.
www.doitpoms.ac.uk/tlplib/microstructural_exam/	Microstructural Examination
www.doitpoms.ac.uk/tlplib/optical-microscopy/index.php	Optical Microscopy and Specimen Preparation
ASTM E7-03	Standard Terminology Relating to Metallography
ASTM Committee E04 on Metallography	Committee E04 on Metallography
www.astm.org/DIGITAL_LIBRARY/STP/PAGES/STP25092S.htm	History of Committee E4 on Metallography

Metallurgy:

www.doitpoms.ac.uk/tlplib/casting/index.php	Casting
www.doitpoms.ac.uk/tlplib/crystallographic_texture/index.php	Crystallographic Texture
www.doitpoms.ac.uk/tlplib/artefact/index.php	Examination of a Manufactured Article
www.doitpoms.ac.uk/tlplib/phase-diagrams/index.php	Phase diagrams and solidification
www.doitpoms.ac.uk/tlplib/solid-solutions/index.php	Solid Solutions
www.doitpoms.ac.uk/tlplib/solidification_alloys/index.php	Solidification of Alloys